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News Briefs

General Developments

Inquiries about News Briefs, where no contact person is identified, should be referred to the Managing Editor, Journal of Research, National Institute of Standards and Technology, Building 101, Room E212, Gaithersburg, MD 20899-0001; telephone: 301/975-3577.

SIMnet LAUNCHED TO FOSTER FREE TRADE IN AMERICAS

When Columbus set sail from Spain in 1492, his goal was to open up trade with the New World. Today, the countries of that New World—the Americas—are starting out on a new trade journey, one that promises unrestricted flow of goods and services among themselves. On Dec. 4, 1998, at NIST's Gaithersburg, MD, headquarters, a step toward realizing that goal occurred with the inauguration of SIMnet, an Internet-based, interactive system for metrology collaboration in the Western Hemisphere.

SIMnet will support real-time comparisons of measurements performed at laboratories throughout the 34 nations that make up the Interamerican System of Metrology (known by its Spanish abbreviation of SIM). SIM's efforts, soon to be enhanced by a fully operational SIMnet, are critical to increasing cooperation in science and technology, eliminating technical barriers to trade and establishing the proposed Free Trade Area of the Americas (envisioned to extend from Alaska to Tierra del Fuego) by 2005.

Organized by NIST and conducted under the auspices of SIM, SIMnet will be pilot tested in a 12-nation intercomparison of high-precision digital multimeters. Participating nations are Argentina, Brazil, Canada, Colombia, Costa Rica, Ecuador, Jamaica, Mexico, Panama, Trinidad and Tobago, the United States, and Uruguay.

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APRIL 1999 CONFERENCE TO SHOWCASE 1998 BALDRIGE WINNERS

The 1998 recipients of the Malcolm Baldrige National Quality Award—Boeing Airlift and Tanker Programs, Long Beach, Calif.; Solar Turbines Inc., San Diego, Calif.; and Texas Nameplate Co. Inc., Dallas, Texas—will present details of their exceptional business practices at the Quest for Excellence XI conference. Presentations covering all seven categories of the Baldrige Award criteria will be made by the CEOs and others in the winning companies.

The conference takes place April 25-28, 1999, at the Marriott Wardman Park Hotel, Washington, DC.

For further information or to obtain a conference brochure, contact the Baldrige National Quality Program at (301) 975-2036. To register for QE XI, contact the American Society for Quality, (800) 248-1946, fax: (414) 272-1734, asq@asq.org.

Information on the 1998 Baldrige Award recipients and the Baldrige National Quality Program is available on the World Wide Web at www.quality.nist.gov.
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UPDATED FIPS LINKS FEDERAL, PRIVATE-SECTOR DATE STANDARDS

NIST recently updated the Federal Information Processing Standard that details how to represent calendar dates in information processing systems. Renamed FIPS PUB 4-2, the revised standard still specifies the use of a four-digit date format to represent the calendar year but

brings the former FIPS PUB 4-1 in line with the date standard developed by the private sector and approved by the American National Standards Institute (ANSI Standard X3.30-1997). The Federal Government uses voluntary industry standards whenever possible.

FIPS PUB 4-2 also incorporates a number of editorial changes to FIPS PUB 4-1.

The original FIPS on calendar date representation was published in 1988 and updated in 1996 to recommend that the Federal Government use the four-digit date format to prepare its systems to handle dates after Jan. 1, 2000. The year 2000, or Y2K, problem refers to the failure of a computer program or system because the "00" year designation is mistaken for "1900."

Federal agencies use FIPS to guide decision making related to the purchase of computer equipment and services. Some private-sector organizations voluntarily adopt them as well.

A copy of FIPS PUB 4-2 is available in electronic form at www.nist.gov/y2k/fips4-2.htm.

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"HOT" NEW STEAM TABLES AVAILABLE FROM NIST

Scientists and others interested in the thermodynamic properties of water will be interested in a new set of "steam tables" from NIST. Tables are provided for the density, enthalpy, entropy, and volume of water and steam calculated from the International Association for the Properties of Water and Steam Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use. The properties are given for vapor-liquid equilibrium conditions at specified temperatures and at specified pressures, and for single-phase states as a function of temperature and pressure.

While users who need high accuracy for scientific research or industrial design should use software that implements the formulation, the printed tables still are needed for quick estimates or when computers are not available. The previous volume containing such tables is outdated.

To obtain copies of the steam tables in NIST Interagency Report 5078, contact Allan H. Harvey, NIST, Boulder, CO 80303, (303) 497-3555, aharvey@boulder.nist.gov.

Media Contact: Fred McGehan, (303) 497-3246; mcgehan@boulder.nist.gov.

DIGEST AVAILABLE ON OPTICAL FIBER MEASUREMENTS

Researchers interested in the characterization of optical fiber and related components will want a copy of the recently published technical digest that chronicles the Tenth Symposium on Optical Fiber Measurements held at NIST's Boulder, CO, laboratories this past September.

Two of the major topics in this compilation of symposium papers are measurements of polarization-mode dispersion and multimode fiber measurement. Fiber geometry is represented in the digest along with the broad topic of fiber mapping with length, including such parameters as chromatic dispersion and polarization properties. Although the focus on multimode fiber measurement may seem outdated, recent developments have brought multimode fiber issues back into the measurement arena.

In all, the digest consists of 44 papers (10 invited and 34 contributed) with two-thirds of the papers originating outside the United States.

Technical Digest, Symposium on Optical Fiber Measurements, 1998, is available at no charge while supplies last. Contact the NIST Optoelectronics Division at (303) 497-5342 for a copy.

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INDUSTRY LOOKS TO NIST FOR REAL-TIME JAVA™ REQUIREMENTS

In response to industry requests to coordinate the effort, NIST established the Requirements Group for Real-time Extensions to the Java™ Platform. Java™ is being deployed in many information technology (IT) areas, far beyond web page applets. Real-time applications and embedded systems are two areas that are being addressed in the Java development arena.

The goal of the Requirements Group is the development of a consensus-based set of real-time functionality requirements for the Java technologies. These requirements then can be input to the Java real-time specification process. The Requirements Group is not writing such a specification and is distinct from any announced specification efforts. Participants in the group include organizations from the embedded computing, manufacturing, academic, development tool provider, and application developer communities. The group is open to all parties interested in developing requirements for real-time Java extensions. NIST provides the forum

for collecting the requirements and will publish the final product of the groups work at http://www.nist.gov/rt-java.
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NIST PROVIDES FOCAL POINT FOR INDUSTRY VPN/IPsec INTEROPERABILITY TESTING

NISTs reference prototypes and online test tools played a vital role in an industry interoperability test event for emerging Internet security protocols. The Virtual Private Networks (VPN)/Internet Protocol Security (IPsec) "bake-off" was held at a private company in Binghamton, NY, in October 1998. NIST's Cerberus/Pluto+ reference implementations of IPsec and IKE (Internet Key Exchange Protocol) served as a test hub and focal point for testing of pre-product implementations from 55 different vendors. NIST's Web-based Interoperability Tester (IPsec-WIT) was used extensively by bake-off participants in the weeks before the event to test and debug their entries in preparation for the bake-off.
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WORLDS FIRST DEMONSTRATION OF IN SITU MBE GROWTH USING X-RAY FLUORESCENCE ENABLES DIRECT FEEDBACK FOR COMPOSITIONAL CONTROL OF FILMS BEING DEPOSITED

A NIST researcher has developed a novel in situ, x-ray-based technique for directly monitoring the composition of ternary and quaternary semiconductor alloys during growth. The result of this effort is the worlds first x-ray spectrum acquired during thin-film deposition in a molecular beam epitaxy (MBE) chamber. Such spectra provide a direct determination of the mole fraction, even in films as thin as 5 nm. The technique is more powerful than other conventional probes that industry uses, such as high energy electron diffraction (RHEED) because it is nonintrusive and nondestructive. Unlike RHEED, the x-ray fluorescence technique does not require a sacrificial sample for instrument calibration.

The probe utilizes a glancing electron beam as an exciter to stimulate x rays from the epilayer growth surface. These x rays are counted and classified by an energy dispersive detector mounted directly on the MBE chamber. The exciter stimulates x rays from the epilayer growth surface even as the sample rotates. The detector is further equipped with a unique window that is not only transparent to the x rays but also capable of cleaning itself as contaminants from the chamber collect at its surface. The window consists of two thin, beryllium metal films, suspended such that the face exposed to the growth ambient can be heated to drive contaminants from the surface. In the past, it has been contamination that has prevented altogether the successful implementation of the x-ray technique.

Benefits derived from direct, in situ x-ray probe will include the improved control of composition in compound semiconductor growth and a significant reduction for industry in expensive post-growth wafer characterization. For the first time, it will be possible to obtain direct feedback for the compositional control of films as they are deposited. This work will enable the improved control of lattice match in complex heterostructures as well as mole fraction reproducibility in III-V semiconductors applied to a variety of opto- and cellular-telephone applications. The research was reported in the Dec. 14, 1998, issue of Applied Physics Letters.
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1.5 μM DISTRIBUTED-BRAGG-REFLECTOR WAVEGUIDE LASERS ENABLE ADVANCEMENTS IN METROLOGY FOR WDM COMPONENTS AND SYSTEMS

Researchers at NIST have demonstrated a monolithic array of single-frequency, distributed-Bragg-reflector (DBR), waveguide lasers. Each laser in the array operates on a different wavelength in the 1.5 μm telecommunications window. The fabrication process can be used to manufacture, on a single glass substrate, lasers that match the wavelength grid established by the International Telecommunications Union (ITU) for wavelength division multiplexed (WDM) optical communications systems. WDM systems considerably increase transmission capacity by simultaneously transmitting information on many wavelengths in the same optical fiber channel.

These lasers will be used in the development of new characterization tools for WDM components and systems. It is often most effective to characterize key components using multiple wavelength channels operating simultaneously. For erbium-doped fiber amplifiers, which are key enabling components in WDM systems, it is necessary to perform tests with many or all channels operating simultaneously. Using individual sources and multiplexers is often prohibitively expensive.

The NIST researchers used Yb/Er-co-doped phosphate glass developed under a cooperative research and development agreement with a private company, to demonstrate a monolithic array of six DBR waveguide lasers. Each laser operated at a single wavelength between 1536.0 nm and 1536.3 nm in this initial demonstration. The lasers were optically pumped at the same wavelength (979 nm) and power levels used to pump erbium-doped fiber amplifiers. The single-frequency operation was stable, with linewidths narrower than 500 kHz.

Future plans for this work include the demonstration of similar laser arrays with each wavelength falling on the ITU grid. They will be used to explore improved measurements of a variety of parameters, including optical amplifier gain and noise figure, channel cross-talk, detector response, and several polarization-dependent characteristics.

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DETERMINISTIC QUANTUM ENTANGLEMENT

NIST scientists recently demonstrated the ability to entangle two quantum particles with high efficiency. This accomplishment could lead to reduced noise in stored-ion frequency standards, and demonstrates the possibility of realistic quantum computation. Previously, entanglement of particle states was obtained by post selection from a large number of trial experiments, such as the production of two correlated photons that occasionally occurs when a single photon passes through a special crystal. Such entanglement has proven useful for tests of quantum nonlocality, but entangling a large number of quantum particles—essential for noise reduction in atomic frequency standards and for building a practical quantum computer—becomes much less likely if it is dependent on a probabilistic process. In the "deterministic entanglement" process, a pair of beryllium ions are confined in an ion trap and laser cooled. Using a predetermined sequence of laser pulses, the internal spin of one ion is entangled with its external motion, and the motion is entangled with the spin of the other atom. Entangled spins are, therefore, obtained "on demand" in each trial. It should be possible to apply the techniques used in these experiments to entangle the states of larger numbers of ions.

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LITHOGRAPHICALLY FABRICATED MICROTRAPS FOR IONS

NIST researchers have designed and fabricated ion microtraps needed for complex work on quantum interactions of arrays of trapped ions. They used lithographic techniques for the first time to produce the linear ion trap from a ceramic substrate with gold-plated electrodes. Lithographic fabrication, in contrast to standard machining, permits more precise control of dimensions for small traps, and allows construction of highly complex trap arrangements needed for future work on the quantum entanglement of larger numbers of ions. Entanglement is the basis for new concepts on quantum computation and quantum-noise reduction in stored-ion frequency standards.

The new lithographic microtraps have been used to trap and crystallize small numbers of laser-cooled ions by using alternating electric fields at frequencies up to 200 MHz. Tightly focused laser beams are used to drive individual ions into desired quantum states and to interrogate the states of each ion. In one experiment using a new microtrap, independent laser beams were focused on each of two trapped ions separated by only about 5 μm, with the off-focus ion receiving only 20 % of the radiation intensity directed at the target ion. Such a high degree of specificity in addressing individual ions is required in many applications of entangled states.

In other experiments, ions have been shuttled along the axis of the trap and separated by applying pulsed voltages to the electrodes. This technique may relax the laser-focusing constraints for quantum logic gates and individual ion detection and suggests the possibility of multiplexing a more complex array of trapped ions by moving ions between accumulators.

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LASER COOLING TO THE GROUND STATE FOR TWO IONS

NIST scientists have cooled two ions to the ground state of motion, an important step in reducing noise in stored-ion frequency standards and in implementing quantum logic operations on multiple ions. Of critical importance is the heating rate and decoherence of the modes of two-ion motion. The group found that the center-of-mass modes of the ion pair are heated at a rate of 5 to 10 quanta per millisecond, similar to previous single-ion results. However, the three internal motional modes (stretch and rocking modes) are found not to suffer from

heating, up to the experimental uncertainty of about 0.1 quanta per millisecond. This is not unexpected, since the internal modes are immune from the effects of noisy fields affecting both ions equally. The heating results indicate that the (unknown) source is not differential heating, thus ruling out sources such as atomic collisions, field gradients, and certain types of rf-micromotion heating.

These results imply that internal modes are more suitable than any center-of-mass mode for use in quantum-logic or noise-reduction schemes. However, any logic operation will be affected to higher order by motion in at least one of the center-of-mass modes, so center-of-mass heating remains a concern.

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NIST-F1: A CESIUM-FOUNTAIN PRIMARY FREQUENCY STANDARD

NIST staff working with a scientist in Italy, have brought NISTs new laser-cooled cesium-fountain frequency standard into operation. The researchers recently completed a preliminary evaluation of the fountain-clock uncertainty at a level commensurate with that of NIST-7 (5×10^{-15}). This evaluation was limited entirely by statistical noise (not systematic effects), since the stability of the standard is still more than an order of magnitude worse than expected performance of the optimized fountain clock. With further development, the uncertainty of this new standard should surpass that of NIST-7 by an order of magnitude.

The narrowest fountain-clock Ramsey fringe observed to date has a width of about 0.6 Hz. The magnetic field applied to separate the Zeeman lines is 0.1 mT, and the Ramsey fringes observed on the first Zeeman line indicate that the field along the flight path of the atoms is uniform to about 10 pT, testifying to the high degree of magnetic shielding.

NIST-F1 differs from fountain frequency standards in use or under development in other national metrology institutes in that the microwave cavity and atom drift tube are an integrated structure that serve as the vacuum chamber for the standard. This design provides exceptional immunity to microwave leakage fields. For all other fountain standards, the microwave cavity and drift tube are contained within a vacuum chamber, and microwave leakage can cause difficulty. The laser system used to generate the multiple beams that cool, trap, and launch the atoms involves a single master-oscillator power amplifier, which provides sufficient power for all of the beams. Other fountain standards typically employ an array of independent diode lasers that are injection locked to a lower-power reference oscillator. Future efforts on this project will focus on improving stability, so that better evaluations can be made of systematic frequency shifts.

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LASERS FOR WAVELENGTH-SCANNED INTERFEROMETRY

NIST scientists are developing rapidly scanned diode lasers for application to wavelength-scanned interferometry. This length measurement process does not require physical movement of the arm of an interferometer. The objective of this joint project is to achieve precision length metrology with systems that can be easily used in a machine-shop environment.

The requirements for the laser system are that it must operate with a single longitudinal and transverse mode, and that its wavelength (oscillation frequency) can be scanned continuously and rapidly without mode jumps. After some study of several laser types, a distributed-Bragg-reflector laser with a three-electrode structure was selected for testing. The 852 nm laser and optics have been enclosed in a "hand-held" 40 mm×40 mm ×100 mm package. A tuning range as broad as 1.3 nm at 852 nm was demonstrated with the period for tuning through the full range being as small as a few milliseconds. The modular electronic systems used to power and control the laser are of a standard design that could be substantially miniaturized if necessary.

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NEW MODE OF EBIT OPERATION ENABLES MEASUREMENT OF EXCITED STATE LIFETIMES

NIST's Electron Beam Ion Trap (EBIT) can remove most of the electrons from any atom and hold the resulting highly charged ion in an electromagnetic bottle for spectroscopic observation. It is, therefore, a valuable laboratory instrument for the benchmark testing of atomic structure models over a wide range of physical parameter space. While most of the benchmark testing with the EBIT has involved measuring the wavelengths of light emitted by the ions, the more difficult but physically complementary method of measuring the decay lifetimes of excited states has been explored only recently.

To measure such lifetimes, manual control of the EBITs electron beam intensity has been taken over by computer. This allows the EBIT to be rapidly alternated between a mixed electric and a pure magnetic trapping mode. The electric mode efficiently produces and

excites the highly charged ions, while the magnetic mode allows a quiet, unperturbed period during which ion fluorescence can be observed cleanly. By automating these cycles in an indefinite loop and having the computer simultaneously record the precise arrival time of each detected photon, it is possible to overlay the data in the form of a decay curve, from which excited state lifetimes can be determined directly.

NIST scientists first proposed this method in 1995, and preliminary decay curves were presented in an invited talk that year at an international conference on atomic spectroscopy. Subsequent development at NIST and elsewhere has proven that the technique can yield accurate data on excited state lifetimes and transition probabilities. The most recent NIST results in Ar^{+13} and Kr^{+22} agree with various theoretical predictions to within 0.2 to 2.2 experimental standard uncertainties.

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X-RAY MICROTOMOGRAPHY OF INTEGRATED CIRCUIT INTERCONNECTS

NIST researchers have obtained the first three-dimensional microscopic images of an interconnect structure buried in the interior of an integrated circuit, using x-ray tomography. This work is a key objective of a NIST-led collaboration, which involving a private company, a University, and a National laboratory.

The images of structures within an integrated circuit were generated by applying NIST-developed tomography algorithms to a set of microradiographs of the circuit taken at the National laboratory. Each microradiograph was acquired for a different angle of incidence between the x-ray beam and the sample surface, and gives information concerning the net absorption of x rays entering the sample at that angle. By applying the tomographic algorithms to microradiographs taken at different angles, a fully three-dimensional image of the circuit structure is obtained. The current images, which show two levels of metalization, connecting vias, and focused ion beam markers with a spatial resolution of 400 nm, are available for interactive viewing (via the Virtual Reality Modeling Language) at http://physics.nist.gov/ppg/xtomo.html.

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EVALUATION MADE OF ELECTRON INELASTIC MEAN FREE PATH DATA

A NIST scientist and a scientist from the Polish Academy of Sciences, recently completed an evaluation of calculated and measured electron inelastic mean free paths (IMFPs) for selected materials. The IMFP is a key parameter in the widely used surface-analysis techniques of Auger-electron spectroscopy (AES) and x-ray photoelectron spectroscopy (XPS). The surface sensitivity of these techniques arises largely from the fact that the IMFP is typically between about 0.3 nm to 5 nm, yet uncertainties in available IMFPs places limits on quantitative surface measurements. A detailed examination has been made of the sources and likely uncertainties in available IMFP values, leading to improved accuracy and reliability in surface measurements.

The major problem is that IMFP has been defined and calculated for bulk solids whereas the measurements have been made in the vicinity of surfaces. Recent calculations have indicated that the effective IMFP near surfaces could be up to 50 % larger than the corresponding bulk IMFPs. A number of approximations have been made in the calculations but the magnitudes of the resulting uncertainties from systematic effects have only been estimated. The relatively new technique of elastic-peak electron spectroscopy (EPES) can measure IMFPs near solid surfaces, but no detailed analysis has been made of the measurement uncertainties.

Materials were selected for which there were calculated IMFPs from at least two sources and EPES-measured IMFPs from at least two sources. As a result, IMFP data for seven elemental solids were examined. Separate evaluations were made for each element of the degree of consistency of the calculated IMFPs and of the measured IMFPs. The calculated IMFPs for each element generally showed high consistency, but the measured IMFPs showed greater scatter. A comparison of measured IMFPs for each element with a function fitted to the calculated IMFPs gave a root-mean-square deviation of $\approx$0.5 nm and an average deviation of 17 %. There was no clear experimental evidence for a surface correction to calculated IMFPs.

IMFP data for Ni, Cu, Ag, and Au showed the greatest overall consistency. IMFPs for these elements over the 50 eV to 10 000 eV range are recommended as reference IMFPs in a new NIST Electron Inelastic-Mean-Free-Path Database to be released soon.

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NIST SCIENTISTS PROVIDE RADIOCARBON ANALYSES FOR SOURCE APPORTIONMENT IN THE NORTHERN FRONT RANGE AIR QUALITY STUDY

NIST scientists collaborated with scientists from a university and two private companies in the Northern Front Range Air Quality (NFRAQ) Study. The main objective of the study was to determine the source of pollution in

Denver, CO, and communities along the Northern Front Range of Colorado so that Colorado legislators could determine viable strategies to reduce the Denver "Brown Cloud," a well-known and extensively studied wintertime air pollution phenomenon. Unfavorable meteorological conditions coupled with high atmospheric concentrations of particulate matter often result in a build up of a polluted and often stagnant air mass in many U.S. regions. Potential adverse human health effects and the accompanying visibility degradation impact the Denver metropolitan area and outlying communities. Particles with an aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$) were the focus of the study. Radiocarbon (^{14}C) analyses of both ambient particulate matter and samples from known pollutant sources were collected as part of the NFRAQ study. The study, mandated by the State of Colorado General Assembly in 1995, resulted in the most scientifically, temporally, and spatially comprehensive examination of urban pollution and visibility degradation along the Northern Front Range, and possibly in the United States. The ^{14}C analyses provided a direct, assumption-free capability to discriminate fossil from biomass carbon source apportionment for particles within the NFRAQ region.

The analyses were performed on particle samples collected during the summer of 1996 and the winter of 1997 from urban (Welby, CO) and rural (Brighton, CO) core sites. The results provided policy relevant information for the Colorado legislators and public health officials. The winter samples showed predominantly a fossil signature suggesting motor vehicle emissions as a main pollutant source. The Welby summer samples also exhibited a predominantly fossil carbon signature, but with a much broader range, which is probably related to the effect of periodic regional biomass contributions, i.e., forest fires or intentional vegetative burning. These results were summarized in a report sent to the governor and state legislators in Colorado.

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DNA MUTATION DETECTION BY CAPILLARY ELECTROPHORESIS

NIST is developing more efficient methods for DNA mutation detection using capillary electrophoresis (CE). Analysis by single-strand conformational polymorphism (SSCP) in slab-gel format is currently the most widely used method to screen genetic mutations before the costly and time-consuming task of DNA sequencing is begun. CE has numerous advantages over slab-gel electrophoresis because it is fast, highly reproducible, and easy to automate. Obtaining unique temperature-dependent mobility profiles with CE-SSCP enhances the prospect for developing an automated system for genetic profiling.

As a diagnostic application, two known mutations within the HFE gene, implicated in the development of human hereditary hemochromatosis, were tested with CE-SSCP. Hereditary hemochromatosis or iron-overload disease is the most common genetic disease in the United States and is potentially fatal but easily treated if diagnosed early. Using CE-SSCP, 20 individual samples were all correctly identified when compared to profiles of reference samples. These findings, obtained in collaboration with scientists from a private company and a university, were presented at the annual meeting of The American Society of Human Genetics. The results will be used in the design of measurement conditions and standards for SSCP and are applicable to the newly developed multicapillary systems that offer high throughput for large-scale screening tests.

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PROTEIN ADSORPTION-RESISTANT SURFACES FOR BIOMEDICAL APPLICATIONS

Interactions between the surface of implanted materials and host tissue are a dominant factor in the effectiveness of innumerable biomedical devices, from blood-contacting devices to artificial hips and tissue engineering scaffolds. The key to many of these processes is to produce surfaces that are resistant to protein adsorption, since receptor-mediated interactions between cells and the adsorbed protein give rise to adhesion of cells to the walls of the device. Poly(ethylene oxide)(PEO) has been recognized as uniquely suited to the prevention of protein adsorption, a key requirement for avoiding the aggregation on cells on devices. The molecular architecture of the grafted PEO chains plays a strong part in determining the PEO layer structure and protein adsorption resistance of these surfaces. Thus it is crucial to understand in detail the polymer chain conformations of the grafted polymer in the presence of water. The technique of neutron reflectivity is uniquely suited for in situ studies of polymer chain conformations at solid-liquid interfaces.

NIST and university scientists recently have performed in situ neutron reflectivity studies, on the NIST horizontal reflectometer, of the conformation of grafted layers of PEO molecules of different architecture to better determine the criteria for obtaining a protein adsorption-resistant surface. PEO molecules with two

different architectures—one with linear PEO chains and the second with star PEO molecules—were used. Linear-chain grafted PEO surfaces were found to be more protein adsorption-resistant than the star PEO grafted surfaces, and the experiments showed that linear-chain PEO grafts covered the surfaces much more evenly than the "fuzzy spheres" of the star PEO grafts. In the case of star polymer grafts, protein adsorption occurs in the seams between stars where the polymer segment density is lower. These results have direct implications for making protein adsorption resistant surfaces for biomedical devices.

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NEW METHOD DEMONSTRATED TO IMAGE POLYMER COMPOSITES

The application of a new imaging technique to non-destructively quantify microstructure and damage in polymer composites has been demonstrated in a collaboration between NIST scientists and researchers at a university. The method, called optical coherence tomography (OCT), is based on interferometric analysis of short bursts of light scattered by the object. Although originally developed at the university for imaging semi-transparent biological tissues, the collaboration has extended the method to produce images of the internal three-dimensional glass fiber architecture in nearly opaque glass reinforced epoxy and vinylester composites. NIST scientists used this information in a fluid mechanics model to yield the first prediction of the reinforcement permeability based on actual fiber architecture. The permeability characterizes the fluid infiltration behavior critical for optimum processing. The technique also was applied to image the fiber distribution and orientation in short fiber samples of interest in the automotive industry. Another application was qualification of surface and subsurface damage for a polymer composite after it was subjected to impact loading. Better methods to image internal defects are a critical industry need since damage to composite laminates is frequently not visible at the surface.

The advantage of this new technique is that it can non-destructively acquire two-dimensional, cross sectional images (6 mm×3 mm) through the intact sample in under a minute at spatial resolutions of about 10 μm. These two-dimensional images then can be assembled into a three-dimensional reconstruction of the material and its internal microstructure. The penetration depth of the light depends on the materials involved, but images extending up to 1 cm into the sample have been obtained. Because the technique is based on light scattering, samples with significant amounts of carbon fiber are a problem, but a variety of composites made with glass or Kevlar fibers have been imaged. One of the most important advantages of OCT is the potential to obtain data at a fraction of the cost for alternative methods. Work is now under way with the automotive, plastics, and offshore oil industries to explore application of OCT to problems in their areas.

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NIST ESTABLISHES A MICROSTRUCTURAL BASIS FOR PROPERTY CHANGES IN CERAMIC THERMAL BARRIER COATINGS DURING THERMAL CYCLING

Plasma-sprayed thermal barrier coating (TBC) ceramic deposits undergo marked changes in their mechanical and thermal properties during in-service thermal cycling. While these changes clearly are related to sintering effects in the microstructure, the anisotropic multi-component nature of this microstructure, together with the complexity and number of plasma-spray process variables, makes it extremely difficult to relate the observed property changes back to the process conditions needed for optimizing a particular TBC design. In collaboration with a university, and a foreign institute, NIST researchers have been applying novel small-angle neutron scattering (SANS) techniques at the NIST Cold Neutron Fecility to address this problem. By quantifying the mean sizes, porosities, surface areas, and anisotropies of each of the major void populations within the microstructure and by following changes in these parameters during thermal cycling, it has been possible to separate out some of the interdependent effects of deposit feedstock powder manufacture and the spray process parameters.

Studies on heat-cycled yttria-stabilized zirconia (YSZ) deposits have shown how changes in the anisotropic elastic properties can be traced to changes in the pore/slat morphology within the deposit microstructure. Provided that all of the feedstock particles are melted during spraying, surprisingly simple monotonic (hence controllable) relationships have been observed between the porosities, surface areas and mean sizes of the void populations, and the feedstock particle morphology. The deposit properties then follow from a weighted function of these component morphologies.

Using a high-temperature furnace designed for in situ SANS studies, the real-time microstructural changes during thermal cycling have been followed. It has been shown that not only is there a preferential sintering out of cracks within the deposit lamellar splat structure

beginning at surprisingly low temperatures (800 °C) but that over hours at more elevated temperatures (1200 °C to 1400 °C), sintering of the interlamellar pore system also is occurring.

The research confirms that large microstructural changes will always occur in the early service life of TBCs, and that these changes are quite separate from the long-term compositional changes that occur, for example, in YSZ TBCs as yttria migrates between zirconia phases. This has implications for the future development of prime reliant ceramic coatings.

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OAE PUBLISHES REPORT ON BASELINE MEASURES

NIST has completed a comprehensive report that details baseline measures for the first of seven national construction goals (50 % reduction in delivery time). Delivery time is defined as the elapsed time from the decision to construct a new facility until its readiness for service. Delivery time issues affect both industrial competitiveness and project costs. Owners, user, designers, and constructors are calling for technologies and practices to reduce delivery time. An Approach for Measuring Reductions in Delivery Time: Baseline Measures of Construction Industry Practices for the National Construction Goals, NISTIR 6189, describes data sources, data classifications and hierarchies, and the metrics used to develop the baseline measures.

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NIST ANALYZES RESIDENTIAL BUILDINGS

NIST has completed an analysis demonstrating that substantial energy savings are possible by making the roof more reflective for a residence without attic insulation located in a hot climate. Buildings in hot climates have long utilized light color construction such as whitewashing to minimize solar heat gains. In recent years, this design philosophy has received renewed attention in the United States, particularly in southern states with hot climates. Using NISTs Thermal Analysis Research Program (TARP), NIST has performed an analysis of the effect of roof solar reflectance on the annual heating/cooling loads, peak heating/cooling loads, exterior roof temperatures, as well as an economic cost analysis of residential buildings. The geographic location of the residential buildings were selected to cover a wide range of climates in the United States, including cold climates (Bismarck, ND, and Portland, ME); intermediate climates (Birmingham, AL, and Washington, DC); and hot climates (Miami, FL, and Phoenix, AZ). The results are published in NISTIR 6228.

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NIST RELEASES BLOCK-PARALLEL CODE FOR DIELECTRIC BREAKDOWN

The CADMUS program models the rapid fractal growth of high-voltage streamers in insulating liquids such as transformer oil. It utilizes NISTs DPARLIB, a Message Passing Interface (MPI) extension of Fortran 90. Results displayed in 3-D show the influence of model parameters on the fractal form and timing. Block execution on parallel processors handles the voluminous calculation of electric voltage fields. An article in the October 1998 issue of Computers in Physics describes and compares the algorithms with experimental results. The web site for the code and a video is http://www.itl.nist.gov/div895/sasg/dielectric/dielabs.html.

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STUDIES OF ARRAYED WAVEGUIDE GRATINGS

A NIST scientist recently returned from a 10-month stay in a leading Japanese laboratory where he studied integrated optic devices known as arrayed waveguide gratings (AWGs). AWGs, which are becoming very important in wavelength division multiplexed (WDM) optical telecommunications, are integrated optic analogs of diffraction gratings and can be used for multiplexing, demultiplexing, and wavelength routing. WDM systems using over 100 lasers, separated in frequency by 100 GHz or less, have been demonstrated in several research laboratories, and systems with more than double this capacity are envisioned. These high-density applications place great demands on the performance and accurate specification of AWGs and other terminal components. While at the Japanese laboratory, the NIST scientist developed and demonstrated a technique that allows measurement of phase errors in the waveguide arms by theoretically compensating for the usually overwhelming effect of chromatic dispersion in the optical fiber leads. He also used optical low-coherence reflectometry to isolate and measure the spectral dependence of small reflections from within the devices.

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OIDA RELEASES "METROLOGY FOR OPTOELECTRONICS" REPORT

The Optoelectronics Industry Development Association (OIDA) has just released a report called Metrology for Optoelectronics, which identifies current and future measurement needs of the optoelectronics industry. It is based principally on an industry workshop organized by the OIDA and hosted earlier this year by NIST. About 30 metrologists from industry and 15 NIST staff members from four NIST laboratories attended the workshop.

The OIDA report observes that "The unmet needs of the optoelectronics industry for metrology are substantial and should be addressed by a more comprehensive, systematic, and organized approach than has occurred to date." It goes on to provide about 35 specific recommendations in seven areas of optoelectronics technology: optical fibers, optical waveguide devices, sources, optoelectronic modules, optoelectronics in computing, optical storage, and imaging. These recommendations, along with similar infor-mation from other associations and standards organizations, will be used to establish NISTs initial priorities for expanded work in this field.
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CIRMS REPORT IDENTIFIES IONIZING RADIATION MEASUREMENT NEEDS

The Council on Ionizing Radiation Measurements and Standards (CIRMS) recently issued its "Second Report on National Needs in Ionizing Radiation Measurements and Standards." Established in 1993, CIRMS represents thousands of users of ionizing radiation and radioactive sources engaged in industrial radiation processing and sterilization, medical radiation diagnostics and therapy, nuclear power generation, worker radiation protection, and environmental measurement programs. The CIRMS national needs reports are important tools to help NIST determine customer needs.

The second report lists 25 measurement needs in four major areas: medical applications, public and environmental radiation protection, occupational radiation protection, and industrial applications and materials effects. Under medical applications, one of the most critical needs is development of national standards for measuring radiation from tiny radioactive "seeds" widely used in treatment of prostate cancer and other conditions. A major need in the environmental area is development of standards to measure how radionuclides interact chemically with different components of soils to aid in clean-up of nuclear waste. Improved electronic personnel dosimetry for radiation workers is a critical need cited under occupational applications. One of the most important industrial measurement needs is dosimetry standards for medical device sterilization.

The CIRMS report includes roadmaps with timelines for responding to these critical measurement needs and notes that "the effort to meet the needs of the user communities for new measurements and standards requires strong collaborative efforts with NIST on the part of medical, industrial, academic and government researchers."

The first CIRMS report (1995) demonstrated the importance of CIRMS in identifying measurement needs. The response to that report, which cited mammography standards as a critical need, NIST co-operated with the Food and Drug Adminstration and a university to develop and disseminate those standards quickly. NIST now operates the mammography x-ray instrument calibration facility to ensure the accuracy of radiation exposure measurements in all 11 000 U.S. mammography facilities.

The 106-page report is available from CIRMS, P.O. Box 1238, Duluth, GA 30136; phone/fax: (770) 622-0026.
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CHANGES TO THE SI PROPOSED

At its 13th meeting held in early September 1998, the Consultative Committee for Units (CCU), one of the nine Consultative Committees that provide advice to the International Committee for Weights and Measures (CIPM), prepared and sent forward to the CIPM three recommendations regarding the International System of Units (SI), the modern metric system. Recommendation U 1 (1998) proposed the special name katal (symbol kat), for the SI unit mole per second (symbol mol/s), for the expression of catalytic activity. This recommendation was in response to a request of the International Federation of Clinical Chemistry and Laboratory Medicine. Recommendation U 2 (1998) proposed the adoption of the special name neper (symbol Np) for the dimensionless derived unit one, for expressing the values of logarithmic quantities such as logarithmic decrement, field level, or power level, while at the same time confirming the CIPM decision to accept for use with the SI the non-coherent unit bel (B), and its commonly used submultiple the decibel, dB. Recommendation U 3 (1998) proposed the introduction of the special name uno (symbol U), for the SI unit one for use with SI prefixes to express the values of dimensionless quantities that are much greater or less than one. Thus one could write the mass fraction is $w = 2\times10^{-6} = 2$ μU, the relative uncertainty of the Planck constant h is $u_r(h) = 8.7\times10^{-8} = 87$ nU, etc.

At its meeting later in September, the CIPM decided (1) to seek the advice of its Consultative Committee for Quantity of Matter (CCQM) regarding the katal before asking the 21st General Conference on Weights and Measures (to be held in October 1999) to formally approve the adoption of the katal; (2) to ask the 21st CGPM to adopt the neper and confirm the continued use of the bel with the SI; and (3) not to introduce the uno at this time but to have the CCU seek the views of potential users of the uno in order to decide if it will be helpful.

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WORKSHOP HOSTED ON LIBRARY OF GREEN'S FUNCTIONS AND ITS INDUSTRIAL APPLICATIONS

NIST hosted a workshop on "Library of Green's Functions and its Industrial Applications," in October 1998; there were 22 participants from NIST, industry, and academia. The objectives of the workshop were to demonstrate the application of a library of discretized Green's functions to industrial problems concerning stress and fracture analysis of materials and to identify industrial problems that can benefit by using the Green's function library and the related boundary element methods. The library of elastic Green's functions is being developed by NIST in collaboration with two universities.

The workshop consisted of brief tutorials on the methods, a demonstration of the library, and hands-on experience with the library for the participants. New boundary element strategies, associated with the library, were included for problems in stress analysis, fracture mechanics, ultrasonic wave propagation, and composite materials. Applications to other areas, such as acoustics, electromagnetic and thermal phenomena, were discussed. The plan is to make the library web based.

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METALLURGICAL PROCESSING GROUP HOSTS WORKSHOP ON MEASUREMENTS IN THERMAL SPRAY COATINGS

NIST hosted a Thermal Spray Coatings Workshop in November 1998. More than 50 attendees representing industry, academia, and national laboratories met to discuss recent advances in sensors, diagnostics, modeling, and control of this important industrial coating technology. Participants expressed their thoughts on the current state of the art and where they feel future research activities need to be focused. The NIST hosts presented results of recent work in plasma spectroscopy, modeling of supersonic jets, and NIST funded external projects on a novel high-speed thermal imaging sensor and unique process control software that simplifies the implementation of expert system truth tables.

Topics of discussion included industry requirements for improving coating reliability, deposition efficiency, and providing rugged and accurate sensors that will interface with currently available control systems. Lot to lot variability of powder feedstock and degradation of the cathode and anode within the plasma torch lead to inconsistent spray conditions, thus degrading coating properties. To address these problems, the participating equipment manufacturers expressed the need for better (less expensive and more rugged) sensors to measure particle temperature, speed, and trajectory within the plasma jet. Various in situ coating sensors such as porosity and surface texture also were listed as desirable process control sensors. The need for developing new yttria stabilized zirconia SRMs in the form of x-ray diffraction (XRD) calibration standards also was high on the priority list. These would be used to measure relative concentrations of the three phases often seen in the metastable, as-deposited thermal barrier coatings used on turbine blades.

As part of the workshop, a new high-resolution, high-speed thermal imaging system developed through a NIST founded project was demonstrated to the participants. This system captures two simultaneous thermal images, each at different wavelengths in the near IR wave bands, with exposure times as short as 50 ns and video framing rates of 30 frames per second. The resulting "streaks" are processed to determine temperature, velocity (speed and trajectory), and size. This technology is targeted at process measurement and control for a variety of materials processing applications such as atomization, spray forming, thermal spray coating, and welding where noncontact thermography of rapidly moving particles and surfaces with varying emissivity is required.

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CAHN AWARDED NATION'S HIGHEST SCIENTIFIC HONOR

John W. Cahn, a leading materials scientist at NIST was named by President Clinton in December to receive the 1998 National Medal of Science. He is the first NIST scientist to be awarded the medal, which is the nation's highest scientific honor.

The National Science Foundation (NSF) announced that Cahn is recognized for his contributions to the

fields of materials science, solid-state physics, chemistry and mathematics. He is most widely known for his elegant theories of how materials transform from one phase to another. These theories have been used by researchers in fields ranging from materials science to astronomy.

During his 40 year career, Cahn has had a profound influence on the progress of materials and mathematics research. He has published approximately 250 scientific papers, delivered 400 invited lectures on his work and received numerous national and international honors and awards.

Cahn, 70, of Bethesda, MD, began working at NIST in 1977, when the agency was still called the National Bureau of Standards. A NIST Fellow since 1984, he is one of nine recipients of the 1998 medal, which is awarded by NSF.

For background information on John Cahn, go to http://www.ctcms.nist.gov/~cahn/ on the World Wide Web. Online information about the National Medal of Science can be found at http://www.asee.org/nstmf/.
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SURVEY ON RETAIL PRICING ACCURACY FINDS MIXED PERFORMANCE

A new survey conducted by the Federal Trade Commission, NIST and weights and measures offices in 37 jurisdictions concluded that pricing accuracy has improved since the first study in 1996. The wrong price, however, was charged for approximately one in 30 items checked in the survey of more than 100 000 consumer products in all types of retail stores. Grocery stores, as a group, had the highest pricing accuracy in the survey with 77 % of inspected food stores passing. Drug stores were next best with 72 percent passing inspection, while 70 % of mass merchandise stores passed and 67 % of department stores passed. Hardware stores had the worst performance in the survey, with a pass rate of 55 %.

NIST and the National Conference on Weights and Measures developed the inspection procedure which state weights and measures inspectors used to assess price scanning accuracy. NIST also provided training in the inspection procedure which is also available to businesses to check their own accuracy.

Price Check II is a follow-up to a 1996 report about the accuracy of prices in stores with electronic checkout scanners. The 1998 study is a larger, more comprehensive review that compares scanned prices with the lowest posted or advertised price of a randomized sample of items in food, department, mass merchandise, drug, hardware and other stores.

More details are available on the NIST World Wide Web site at http://www.nist.gov/public_affairs/releases/scanner.htm. Copies of the 1998 and 1996 Price Check studies, as well as consumer and business education materials, are available from the FTC's web site at http://www.ftc.gov and also from the FTC's Consumer Response Center, Room 130, 600 Pennsylvania Avenue, N.W., Washington, DC 20580, (202) FTC-HELP (382-4357).
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SUPERCONDUCTING SENSOR PROVIDES MORE SENSITIVE AC MEASUREMENTS

Engineers measure ac voltage or current by using devices called "thermal transfer standards." When an unknown ac signal is applied to the device, its temperature rise is recorded. A known dc current is then applied and adjusted until the same temperature rise is reached. This establishes a comparison between the unknown ac and known dc signals. If the ac-dc difference of the transfer standard is known (a quantity determined by NIST) and if the dc signal is known, then the ac voltage or current can be determined.

Present thermal transfer standards operate at room temperature, and are limited by the performance of their temperature sensors and by other effects that can be reduced at very low temperatures. Therefore, a NIST research team designed and built a new prototype standard cooled with liquid helium that uses a much more sensitive, superconducting temperature sensor. The new device operates at cryogenic temperatures, that is, below 10 K.

Because of its high sensitivity, the superconducting sensor runs at millionths of a watt, where conventional thermal-transfer devices may require more than a hundredth of a watt to operate. This reduction in operating temperature and power allows for comparisons at unprecedented low signal levels with an uncertainty comparable to (and potentially better than) the best room temperature comparisons.

For more information, contact Joseph R. Kinard, NIST, 100 Bureau Drive, Stop 8111, Gaithersburg, MD 20899-8111, (301) 975-4250, joseph.kinard@nist.gov.
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FedCIRC PASSES TEST, BEGINS PERMANENT SERVICE

NIST has completed a highly successful pilot project designed to protect the federal government's computer systems from attacks.

NIST, with operational support from Carnegie Mellon University's Software Engineering Institute Computer Emergency Response Team Coordination Center and the Department of Energy's Computer Incident Advisory Capability, pioneered the Federal Computer Incident Response Capability. FedCIRC, launched by NIST in 1996, provided the first comprehensive computer incident handling capability to the Federal Government's civilian agencies. During the 2 year pilot project managed by NIST, FedCIRC staff handled nearly 2000 problems ranging from computer viruses to unauthorized system intrusions.

The Federal Government's General Services Administration is now managing FedCIRC, and CERT/CC handles FedCIRC's day-to-day operations.

NIST no longer hosts the FedCIRC web site, which is now at http://www.fedcirc.gov. Inquiries should be directed to fedcirc@fedcirc.gov or (888) 282-0870.
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NEW PAPER DISCUSSES STANDARDS ACTIVITY FOR NDE

Researchers in welding and the general field of nondestructive evaluation (NDE) will want to obtain a new paper from NIST that details the standards activities and organizations, both domestic and international, that affect them.

The paper discusses the International Standards Organization (ISO) and its role in promoting the development of standards and related activities throughout the world. ISO lists 64 standards that apply directly to the inspection of welds in structures. Both the technical and administrative aspects of ISO are discussed.

In particular, the paper focuses on ISO Technical Committee 135 which covers nondestructive testing. The American National Standards Institute and other organizations involved in welding standards also are profiled.

For a copy of paper no. 48-98, The International Standards System and NDE, contact Sarabeth Harris, MS 104, NIST, Boulder, CO, 80303-3337, (303) 497-3237; sarabeth.harris@nist.gov.
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SCIENTISTS DEFINE COMPLEX CHEMISTRY IN CHIP MAKING DEVICES

NIST scientists are among the first to identify and measure the types of ions generated from gases used to process computer chips in the inductively coupled plasma reactor, a device rapidly becoming a favorite of the semiconductor industry.

The inductively coupled plasma reactor, steadily replacing its capacitively coupled predecessor because of the higher quality microchips it creates, might be made more efficient if the complex chemistry taking place inside was better understood. Such knowledge could enable engineers to design reactors that consume less electricity and lower quantities of the required gases, some of which may contribute to global warming.

Both reactors work by ionizing gases into plasmas and triggering a series of chemical reactions. Researchers suspected that the inductively coupled reactor produced a far more complex combination of ions than the capacitively coupled version, making it extremely difficult to predict reaction outcomes and formulate theoretical models needed to improve the new device.

Now, NIST researchers have confirmed that inductively coupled plasma reactors do indeed produce a complex brew of ions. They also identified the specific ions and measured their proportions. The findings were reported in two research papers delivered during recent scientific conferences.

The research also raised further questions, when under certain conditions, different results were obtained in two seemingly identical reactors at NIST and Sandia National Laboratories. This means there are parameters that have yet to be adequately quantified.

For more information, contact James K. Olthoff, NIST, 100 Bureau Drive, Stop 8113, Gaithersburg, MD 20899-8113, (301) 975-2431; james.olthoff@nist.gov.
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DSS EXPANSION BROADENS FEDERAL IT SECURITY CHOICES

Upon NIST's favorable recommendation, the Secretary of Commerce has expanded the Digital Signature Standard (DSS), clearing the way for federal agencies to choose from a broader field of computer security products.

Digital signatures confirm the identity of the signer and verify that electronic information has not been altered. They are gaining wide use in electronic commerce transactions.

The DSS was approved in 1994. It specified the use of a single technique for generating signatures using the Digital Signature Algorithm. Mathematical formulas called algorithms are at the heart of computerized encryption systems and various other computer security products.

In 1997, NIST announced that it was considering revising the standard to allow for other algorithms in generating digital signatures. The notice specifically mentioned the possibility of adding RSA (a private company) and elliptic curve techniques for generating signatures, and asked for public comments. These overwhelmingly supported a revision.

The revised federal standard allows for the RSA technique. This follows the recent approval of an RSA standard (X9.31) by the private-sector American National Standards Institute (ANSI). ANSI is expected to approve a standard based on the elliptic curve technique in the future.

The revision of the federal standard will greatly increase the number of off-the-shelf digital signature products that Federal agencies can buy.

NIST, in a recent Federal Register notice, asked for public comments on the revised standard, which is formally known as Federal Information Processing Standard 186-1, Digital Signature Standard. The public may send comments to the Information Technology Laboratory, Attn: DSS/X9.31 Comments, NIST, 100 Bureau Drive, Stop 8970, Gaithersburg, MD 20899-8970. Comments may be sent electronically to FIPS 186RSA@nist.gov. Specifications of the FIPS 186-1 are available electronically at http://csrc.nist.gov/fips/.

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THREE TIMES DES IS FORMULA FOR INFO SECURITY SUCCESS

NIST has published a proposed revision of the Data Encryption Standard (DES), which Federal agencies (and many other organizations) use to scramble sensitive information. Public comments currently are being sought on the proposal—using the DES algorithm in three successive operations, a technique known as Triple DES.

The revised DES applies to Federal agencies that use encryption to safeguard sensitive, unclassified information. The original version of the DES standard was first approved in 1977 and has since been revised several times.

Triple DES offers a higher level of security than single DES. This change will require Federal agencies that are purchasing encryption systems to buy products that use Triple DES. NIST advises agencies that currently employ single DES to make a transition to Triple DES. NIST first recommended Triple DES to Federal agencies in an Information Technology Laboratory Bulletin issued in September 1997.

Both DES and Triple DES are used widely in the private sector, particularly in the financial services industry. In fact, the proposed revised standard points directly to a Triple DES standard recently approved by the banking standards community.

Triple DES is intended to bridge the gap between DES and the future Advanced Encryption Standard (AES), which currently is under development by NIST's Information Technology Laboratory. The AES is designed to provide strong cryptographic security well into the 21st century.

NIST, in a recent *Federal Register* notice, asked for public comments on the revised standard, which is formally known as Federal Information Processing Standard 46-3, Data Encryption Standard. The public may send comments to the Information Technology Laboratory, Attn: Review of Draft FIPS 46-3, NIST, 100 Bureau Dr., Stop 8970, Gaithersburg, MD20899-9870. Comments also may be sent via electronic mail to desreview@nist.gov.

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1999 BALDRIGE CRITERIA GET A NEW LOOK, FORMAT

While you won't find it at your local bookstore or on a bestseller list, the *Baldrige Criteria for Performance Excellence* is one of the Nation's most popular organizational improvement publications.

The 1999 criteria sport a new, easier-to-use format, which includes a series of questions covering seven key areas: leadership, strategic planning, customer and market focus, information and analysis, human resource focus, process management, and business results. Over the years, NIST has revised and streamlined the criteria to focus more sharply on overall performance excellence and business results as integral parts of today's management practice.

Thousands of U.S. organizations, for-profit businesses, as well as others use the criteria to assess and improve their overall performance. Since 1988, more than a million and a half copies of the Baldrige Criteria for Performance Excellence have been distributed, and wide-scale reproduction by companies and electronic access add to that number significantly.

The criteria have been tailored for three different audiences: for-profit businesses, health care providers and educational organizations. Single copies of the *Baldrige Criteria for Performance Excellence* are available free of charge from NIST by calling (301) 975-2036, faxing a request to (301) 948-3716, sending e-mail to nqp@nist.gov or accessing the World Wide Web at address http://www.quality.nist.gov.

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NIST'S CRYPTOGRAPHIC MODULE VALIDATION PROGRAM VALIDATES FIRST LEVEL 4 MODULE

In November 1998, the IBM 4758 PCI Cryptographic Coprocessor became the first cryptographic module to be validated by NIST's Cryptographic Module Validation (CMV) Program as meeting Federal Information Processing Standard (FIPS) 140-1, Level 4. The 4758 module is a tamper-responding, programmable, cryptographic PCI card, containing CPU, encryption hardware, RAM, EEPROM, hardware random number generator, time-of-day clock, firmware, and software. This validation is a major milestone for the CMV Program, since many critics believed Level 4 was unobtainable. This is the second major milestone for the program this calendar year; the first was the Level 3 validation issued in May 1998.

The CMV Program has experienced exponential growth during the past year, with over 30 cryptographic modules being validated as conforming to FIPS 140-1, Security Requirements for Cryptographic Modules. FIPS 140-1 specifies four separate levels of security provided by Cryptographic Modules, with each level providing increased security and assurance. Security Level 4 provides the highest level of security. Of the 27 modules validated this year, nine are Level 1, 11 are Level 2, six are Level 3, and one is Level 4. Additional modules are expected to be validated in the near future, since approximately 30 modules are currently in the testing phase of validation.

The recent validations impact Federal agencies by further increasing the number of cryptographic products available for use in securing sensitive information. With the addition of the first FIPS 140-1 Level 4 validation, Federal agencies now have 38 modules covering all security levels to meet their cryptographic needs. Of the 38 total number of validated modules, 14 are Level 1, 17 are Level 2, six are Level 3, and one is Level 4.

The CMV program is a joint effort between NIST and the Communications Security Establishment (CSE) of the Government of Canada. NIST and CSE serve as the validation authorities for the program.

For more information on FIPS 140-1, validated modules, and the accredited laboratories, see the web site at http://csrc.nist.gov/cryptval.

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NIST WORKS WITH INDUSTRY TO UPDATE THE DIGITAL SIGNATURE STANDARD TO ALLOW USE OF RSA

The Secretary of Commerce recently approved NISTs modification of the Digital Signature Standard (DSS) to allow for the use of the RSA digital signature technique, perhaps the most widely used signature algorithm in the private sector today. Specified in Federal Information Processing Standard (FIPS) 186-1, the modified DSS gives Federal government users the option of using either the Digital Signature Algorithm (DSA), the Federal government standard since May 1994, or the RSA algorithm, as specified in a recently approved banking standard, ANSI X9.31.

In the summer of 1997, NIST solicited the public and private sectors for comments on the potential adoption of RSA as an approved signature technique. The response was overwhelmingly positive. Since that time, NIST has worked with the ANSI X9F1 working group (whose secretariat is the American Bankers Association) to develop ANSI X9.31, the standard that specifies the RSA signature algorithm. Currently, NIST is working with X9F1 and RSA Laboratories to develop a validation testing document that will be used in the future by accredited laboratories to test the conformance of commercial, off-the-shelf (COTS) products to the X9.31 standard.

Digital signature technology provides an electronic equivalent to handwritten signatures. It can authenticate the signatory of data, enable the detection of data modification, and allow a third party to verify the signatorys identity. Such technology is a critical component for secure electronic commerce. The updated FIPS 186-1 gives government agencies greater options for protecting their sensitive data using strong cryptography. COTS vendors have the potential to sell more of their products to the government sector, and all users in the public and private sectors who want to use tested security products for signing data have more COTS products from which to choose.

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DEMONSTRATION OF BIODEGRADABLE ENVIRONMENTALLY SAFE, NONTOXIC FIRE SUPPRESSION LIQUIDS

NIST has completed the first comprehensive examination of the fire fighting effectiveness of environmentally friendly fire suppression agents for use on Class A, B, and many D fires. Accepted test procedures for measuring the suppression effectiveness of water-based fire fighting agents do not currently exist. The results of this study are a first step toward establishing standardized tests for evaluating their fire fighting effectiveness. The study was conducted under the sponsorship of the U.S. Fire Administration. A wide variety of cooperative research, involving public and private organizations, was required to conduct the study.

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NIST ESTIMATES NATIONWIDE ENERGY IMPACT OF VENTILATION AND INFILTRATION IN U.S. OFFICE BUILDINGS

NIST has estimated the energy consumption due to entilation and infiltration in U.S. office buildings and found it to be significant. The impact of infiltration in U.S. office buildings is 60 PJ (60×10^{15} J) of heating energy (15 % of the total heating energy) and 6 PJ of cooling energy (4 % of the total cooling energy). Tightening building envelopes could reduce the impact of infiltration by 26 % for heating and 15 % for cooling, and properly pressurizing buildings could reduce the impact of infiltration by 19 % for heating and 58 % for cooling. Heating and cooling energy use due to ventilation in U.S. office buildings is between 17 PJ and 138 PJ, depending on the amount of outside air required to meet indoor air quality standards. In order to estimate the national energy impacts, this analysis was performed on a set of 25 buildings that represent the U.S. office building stock as of 1995. These results were reported at a conference in October 1998.

NIST has completed a study of the airtightness of the building envelopes of commercial and institutional buildings. Based on data collected over 15 years in the United States, Canada, and Europe, the study found that there are significant levels of air leakage in these buildings and that they do not correlate with building age, size, or construction. The average leakage value for the office buildings in this study is 25 m^3/h per square meter of wall area at a pressure difference of 75 Pa, which corresponds to a typically leaky U.S. home. It is often assumed that commercial and institutional buildings are airtight and that envelope air leakage does not have a significant impact on energy consumption and indoor air quality in these buildings. Furthermore, it also is assumed that more recently constructed buildings are tighter than older buildings. Prior to this study, very little data were available on the airtightness of building envelopes in commercial and institutional buildings. This research was also presented at a conference and will lead to improved predictions of building energy consumption and indoor pollutant levels.

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NIST RESEARCHERS EXPLAIN A UNIQUE MULTIPHASE FLOW PHENOMENON

The transport of small particles through gaseous or fluid wakes is a common phenomenon found in many technological and natural processes in such areas as power generation and pollution control. Approximately a decade ago it was discovered that the conventional wisdom that turbulence in these wakes invariably results in effective particle mixing is not always true. It was determined that particles in certain size ranges sometimes “demix” by concentrating along the peripheries of the wake vortices, a phenomenon referred to as “focusing.” No convincing explanation could be given for this nonintuitive particle behavior, although chaos was sometimes invoked as a controlling factor. Recently, however, a NIST investigation has elucidated the underlying physical mechanism behind this focusing phenomenon. Utilizing a combination of theoretical and computational techniques, NIST researchers have demonstrated conclusively that a particle attractor exists in these types of flows and have mapped its behavior as a function of particle size. They also have demonstrated convincingly the important role that centrifugal force effects play in flinging the particles toward the vortex peripheries. Finally, they have proven mathematically that chaos plays no role in this type of particle behavior. The results of this research will appear in a paper in the *Journal of Fluid Mechanics.* These results ultimately could lead to improved designs for such multiphase flow devices as combustors where focusing is clearly a phenomenon to be avoided.

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EXPERIMENTAL MEASUREMENTS VERIFY DESIGN METHODS FOR HEAT EXCHANGERS CONTAINING SUPERCRITICAL FLUIDS

NIST researchers have measured the thermal performance of a typical process heat exchanger containing supercritical carbon dioxide (7.38 MPa critical pressure, 31.1 °C critical temperature) heated by hot water. Supercritical fluids have become increasingly important as alternative fluids in modern technologies such as destruction of organic wastes, chemical synthesis and extraction, precision cleaning, and as working fluids in refrigeration and heat pumps. Because the properties of a fluid vary considerably with small changes in the thermodynamic state near the critical point, flow behavior and the transport of heat are very different in this regime and must be studied carefully to develop accurate predictive methods for process design. The heat exchanger tested was a horizontal tube, 2.74 m long by 10.9 mm inside diameter, with hot water flowing countercurrent on the outside of the tube. Measurements were made at operating pressures from 7.8 MPa to 13.1 MPa, flow rates from 1.0 kg/min to 5.1 kg/min, heating rates from 1150 W to 6180 W, and inlet temperatures from –1.7 °C to 32.7 °C.

The results showed significant differences in thermal performance for the supercritical fluid when compared to a constant property fluid: conditions of high flow rate and low heating rate enhanced the heat transfer for the supercritical fluid, while conditions of low flow rate and high heating rate degraded the heat transfer for the supercritical fluid. The measured rate of heat transfer can be predicted by an engineering correlation, developed for supercritical flows with constant heating at the tube wall, to within 3 % (one standard deviation estimate). This correlation now can be used confidently as a design method for industrial processes utilizing supercritical fluids.

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INFRARED SPECTROSCOPIC ELLIPSOMETRY FOR BIOMOLECULAR MATERIALS CHARACTERIZATION

NIST scientists are making it easier to extract molecular level details from infrared spectroscopy. Infrared spectroscopy is used to characterize organic films for many applications, from lubrication to drug screening to computer chips. Vibrations in molecules, which are probed at infrared wavelengths, can provide information about molecular identity, conformation, and orientation. The scientists are developing software that will allow users to easily apply sophisticated calculations using electromagnetic wave theory to extract quantitative structural information from their data. They also are developing procedures that will permit more widespread use of infrared ellipsometry measurements. Infrared spectroscopic ellipsometry can provide all the information of infrared spectroscopy, plus allow determination of the thickness of a surface layer. A low-cost, simplified infrared spectroscopic ellipsometer has been constructed by the scientists, and data are analyzed with an improved electromagnetic wave theory model. Using self-assembled monolayers and lipid bilayer membranes as reference materials, the researchers have confirmed that they can quantitatively evaluate molecular conformation and orientation at the same time that they can quantitate film thickness, with a signal-to-noise ratio that exceeds that of current commercial instruments. This new approach to infrared ellipsometry, coupled with the data analysis software, will allow the study of conformational changes that occur during the binding of drugs to biological membranes. These advancements will also make high-precision structural characterization of thin-film materials accessible to more users.

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NIST APPLIES FOCUSED ION BEAM PATTERNING TO FABRICATE QUANTUM-CONFINEMENT STRUCTURES

NIST scientists have applied focused ion beam (FIB) patterning to fabricate a pseudomorphic high-electron-mobility transistor, or pHEMT. This is the first known structure exhibiting quantum confinement fabricated by the FIB method, which does not require expensive optical lithography, thermal, or chemical processing steps that are conventionally used to fabricate such structures. The transistor is based on a multilayered InGaAs/AlGaAs materials system, which forms a two-dimensional conducting electron gas confined to the active layer (InGaAs). The FIB 25 keV beam of Ga^+ ions makes it possible to further confine the gas in the *x-y* direction with 100 nm placement accuracy, by forming boundaries of high resistivity where the ions are selectively implanted. Electrical performance characteristics of the transistor are typical of conventionally fabricated pHEMTs, confirming the cost and time-saving advantages of the FIB approach.

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WIDEBAND HIGH-CURRENT SHUNT WILL EXTEND NISTS CALIBRATION SERVICE OF CURRENT MEASURING DEVICES

A wideband (100 kHz), high-current (100 A rms) shunt has been developed by NIST that promises to provide an important standard for extending the calibration service of current measuring devices. Presently, the NIST calibration service for determining the ac-dc difference of current shunts is limited to current levels up to 20 A at frequencies up to 100 kHz. The new shunt will act as a NIST standard for calibrating shunts and current transformers at current levels up to 100 A and frequencies up to at least 10 kHz as a NIST special test.

The impetus for this work was driven in part by the U.S. Air Forces requirement for traceability to NIST of current shunts in support of their acquisition of a new commercial 100 A, 100 kHz transconductance amplifier that is now on the market. This new amplifier is a commercial version of a NIST-developed 100 A, 100 kHz transconductance amplifier. Several manufacturers have taken an interest in commercializing the NIST design to meet the needs of military calibration laboratories. Industry also requires high-current/high-frequency traceability to NIST for several applications, including high-frequency welding techniques, harmonic power measurement (utilities), and current measurements in high-current switching supplies (power supply manufacturers).

The newly developed shunt is essentially an in-line coaxial four-terminal resistor, having high-current coaxial input and output current connectors together with a separate potential connector. Unlike line terminating shunts, the in-line configuration design allows for an unknown device to be inserted in the current circuit while maintaining a coaxial environment. As such, this configuration is ideal for comparing other current measuring devices such as shunts and current transformers.

The approach has been to use the excellent stability and high-frequency characteristics of low-power metal film resistors in a large parallel array. There are 250, 1 Ω axial-leaded metal film resistors soldered between double-sided printed circuit board "plates" that provide a nominal 4 mΩ resistance. Separate potential leads connected to the inside copper layer provide the potential connection. The entire array is potted inside the coaxial enclosure with a room temperature curing silicone rubber, exhibiting very high thermal conductivity with high insulating qualities. This compound provides a low thermal resistance from the resistor elements to the finned heat sink outer case. In addition, forced air cooling results in a thermal equilibrium achieved in under 30 min at 40 W of power dissipation. Preliminary tests show a flatness in the frequency response better than 5×10^{-4} Hz to 20 kHz, and under 2×10^{-3} Hz to 100 kHz, which is an order of magnitude improvement in performance over what industry presently is able to provide.

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PROTOTYPE OF MATH DIGITAL LIBRARY RELEASED

An early prototype of the NIST Digital Library of Mathematical Functions (DLMF) has been released for public inspection and comment. The DLMF is designed to be a complete and authoritative online reference on the definition and properties of mathematical functions that occur in applications. Examples include Bessel functions, hypergeometric functions, and various classes of orthogonal polynomials. The DLMF, which will be freely available via the World Wide Web, will contain more than 30 "chapters;" each is centered on a class of functions, authored by recognized authorities.

The emphasis is on information useful in applications, as well as on methods of computation. The online reference work will contain many complex mathematical formulas that can be downloaded into word processors and symbolic computing systems, graphics that can be manipulated by users, as well as tables of relevant numerical quantities, some of which will be computed on demand. Math-enabled search facilities will guide users to relevant information, including pointers to software that compute various functions.

The DLMF is inspired by the *NBS Handbook of Mathematical Functions* (AMS 55, M. Abramowitz and I. Stegun, NBS, 1964), which has sold more than 100 000 copies and remains popular today. The DLMF is expected to contain more than twice as much technical information as AMS 55, reflecting the continuing advances of the intervening 40 years, while eliminating most of the tables as unnecessary for todays needs. The newly released prototype, at http://math.nist.gov/DigitalMathLib/, is designed to show the scope of the planned project, which is just under way. It contains a complete chapter on the Airy function and a chapter on applications. These are designed to be used as models for other authors. The DLMF is expected to be completed in 2002.

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FIRST LIGHT FROM THE UPGRADED SURF III STORAGE RING

On Dec. 17, 1998, just 3 days into the commissioning process, the first electron beam was stored in SURF III, the successor to the SURF II synchrotron radiation source at NIST. This achievement caps a 16-month, $1.5 million effort to replace the 25-year-old SURF II electron storage ring with a new accelerator optimized for radiometry. SURF III was carefully designed, constructed, and assembled to exacting specifications to produce a magnetic field with an azimuthal uniformity of 1×10^{-4}, a factor of 50 improvement over SURF II, and a maximum electron energy of 400 MeV, compared to SURF II's maximum of 300 MeV. The improved magnetic field uniformity greatly increases the accuracy of calibrations using SURF III as a standard source. The higher electron energy extends the short-wavelength limit of the useful radiation from 4 nm to 2 nm, opening the "water window" for high-contrast biological imaging. The result of this upgrade project is a world-class radiometry facility serving as the U.S. national standard of irradiance in the vacuum ultraviolet and as an intense, continuum source of radiation spanning the electromagnetic spectrum from the infrared to soft x rays.

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1998 EDITION OF NIST SP 739 PUBLISHED

The 1998 edition of SP 739, *Directory of Federal Government Certification and Related Programs,* has been published and is available at http://ts.nist.gov/ts/htdocs/210/216/216.htm. The document contains information on federal government procurement and regula-tory conformity assessment programs that might affect products and services. Since the previous edition, many new federal programs have been identified and changes have been made in previously listed entries to reflect organizational or programmatic changes. The documents scope has been expanded to include conformity assessment and other types of federal programs that have an impact on the marketplace.

Federal conformity assessment procedures provide assurance that the products and services regulated or procured by federal agencies have the required characteristics and/or perform in a specified manner. The methods used by federal agencies to ensure conformance may be quite different from those traditionally employed by the private sector, including third party certifiers. Agency conformity assessment procedures may include sampling and testing, inspection, and/or certification by the agency or other specified organization; licensing; product listing; the submission to an agency of manufacturing, operational, and related data for review; manufacturer self-declaration of conformity to agency requirements; mandatory labeling and advertising requirements; establishment of national requirements that are adopted/enforced at state and local government levels; issuance of regulatory guidelines; pre-marketing approval requirements; post-marketing monitoring requirements; and the conduct of environmental impact assessments. Interest in such programs has increased due to growing awareness of their impact on trade and the increasing obligations placed on federal agencies to consider the effect of their regulatory and procurement actions both domestically and in global markets.

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NONDESTRUCTIVE CHARACTERIZATION OF RADIATION EMBRITTLEMENT

NIST researchers are developing nondestructive measurement techniques to detect the embrittlement produced by radiation damage in reactor pressure vessel steels. This has demanded that the measurements be performed on specimens exposed to neutron irradiation in an operating reactor for long periods of time and which have known values for the mechanical properties as a function of neutron fluence. The Nuclear Regulatory Commission (NRC) maintains a set of such specimens, but they are radioactive and can be tested only by manipulators operating inside a "hot cell." NIST has developed ultrasonic and micromagnetic techniques that can sense embrittlement similar to radiation embrittlement. Two of these techniques were used by NIST staff to make measurements on 16 NRC samples in the hot cell. These are the velocity of ultrasonic shear and Rayleigh waves with an uncertainty of less than 0.1 % and a measurement of the magnetostrictive coefficient as a function of applied field. Because of the varied histories of the specimens in the NRC collection, the data must be analyzed carefully before any correlations with radiation-induced embrittlement can be established.

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POWDER METALLURGY TECHNOLOGY IMPROVED

Powder metallurgy (PM) is a process for making parts using powdered metals. The process involves pressing and heating molded powder until nearly full density is obtained. It is an extremely cost-effective process for making complex shapes without machining. It also is an environmentally benign process, with little waste of material or production of emissions. The automobile producers are particularly fond of PM for making gears, sprockets, and pump rotors. They have plans to greatly increase the use of PM in car making and to develop PM for aluminum alloys and composites. NIST has been actively involved in these industrial efforts for more than a decade, providing modeling and understanding of the process to increase the productivity and competitiveness of the U.S. PM industry.

Particularly in the manufacture of metal-matrix composites (MMCs) by powder metallurgy, the optimum mechanical properties are obtained by the use of very small powder particles. Such fine powders do not flow freely into dies unless the powder particles are spherical in shape, but spherical powders are high in cost. A commercially viable approach to the use of low-cost, fine, nonspherical powders in the PM manufacture of MMCs required development of a reliable way to fill dies uniformly and repeatably.

Recently, NIST and a private company have developed a powder feeding system that will allow lower cost powders to be used in a variety of parts. Furthermore, the powder feed system results in a factor of four reduction in part mass variability with a consequential increase in dimensional accuracy and decrease in distortion.

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TEMPLATE POLYMERIZATION OF ROD-LIKE MICELLES

The polymerization of emulsions or microemulsions produces polymer particles (latexes) of 20 nm to 10 000 nm diameter. These typically spherical latex particles find everyday use in paints and adhesives and can be used as nanoscale templates for fabricating electronic devices or composite materials. Polymerization of spherical micellar structures produces even smaller structures of 3 nm to 5 nm, still retaining a globular shape. However, in rod-like micellar systems, the surfactant aggregates are highly anisotropic cylinders of 4 nm diameter, with lengths of 1000 nm or longer. For the first time, these structures have been polymerized, retaining their anisotropy.

The novel monomeric surfactant cetyltrimethylammonium 4-vinylbenzoate was polymerized by free-radical initiation in aqueous solution. Small-angle neutron scattering (SANS) studies at the NCNR of MSEL were used to follow the structural evolution in real-time throughout the polymerization reaction. Analysis of the SANS data shows that the cylindrical cross-section (4 nm) of the parent micelles is retained after reaction, and the length of the polymerized micelles is controlled by the degree of polymerization and can be from 40 nm to 160 nm long. The final polymerized product is one of semi-rigid, discrete cylinders, with essentially no surface charge. These polymerized micelles are stable to dilution, temperature, and electrolyte addition. This is in sharp contrast to the parent micelles that reorganize their structure in response to changing solution conditions. The simple synthesis and interfacial nature of the polymerization lends itself to easy functionalization of the particle surfaces.

Aside from their fundamental usefulness as a model rod-like colloidal system, the polymerized micelles can be used as templates for composite materials that exploit the anisotropy of the particle.

The methodology demonstrated here for converting self-assembled molecules into structurally stable materials with novel nanoscale morphology and surface functionality holds great promise, for example, for applications in catalysis, chemical separation by selective adsorption, and control of rheological behavior in chemical processing.

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DEVELOPMENT OF INTERNATIONAL STANDARDS FOR SURFACE ANALYSIS

Two NIST staff members participated in the recent meetings of the International Organization for Standardization/Technical Committee (ISO/TC) 201 on Surface Chemical Analysis held in Matsue, Japan, in October 1998. They were among the more than 60 delegates from various countries. The main objectives for NIST staff were to provide U.S. input in standards needs and potential solutions as well as to help establish a U.S. position in this important area of metrology, thus aiding the Nation in establishing international traceability.

Surface analysis is in widespread use throughout the world for the characterization and development of advanced materials and processes, including nanostructured materials, electronics, and catalysts. Although many successful applications have been demonstrated,

standards are needed to assist scientists in making efficient and reliable analyses and to facilitate the development of quality management systems required for ISO 9000 certification. ISO/TC 201 was formed in 1991 to develop internationally recognized standards for surface analysis.

The eight subcommittees and 15 working groups of ISO/TC 201 are developing standards for the different techniques in common use for surface analysis. At present, one ISO standard has been issued, 10 potential ISO standards are at various stages of approval, and 18 potential work items are under active consideration. The following illustrate the range of work under way:

- vocabulary for surface chemical analysis,
- preparation and mounting of specimens for analysis,
- ion-implanted surface analytical reference materials procedure for standardizing the retained areic dose in a working reference material,
- determination of boron content in silicon using uniformly doped materials,
- method for depth profiling of boron in silicon by secondary ion mass spectrometry,
- optimization of sputter-depth profiling using single-layer and multilayer reference materials,
- calibration of the energy scales of x-ray photoelectron spectrometers, and
- description of selected instrumental parameters in x-ray photoelectron spectroscopy.

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BROADBAND WIRELESS STUDY GROUP ESTABLISHED IN RESPONSE TO PROPOSAL BY NIST'S N-WEST DIRECTOR MARKS

The drive toward Broadband Wireless Access (BWA) standardization gathered momentum when, in November 1998, the world's most influential network standardization body chartered a Study Group on Broadband Wireless Access. By unanimous vote, the charter was granted by the LAN/MAN Standards Committee (also known as the "802" Committee), an arm of the Computer Society of the Institute of Electrical and Electronics Engineers (IEEE). IEEE 802 publishes standards that define much of the world's wired and wireless local and metropolitan area networks. The IEEE's Microwave Theory and Techniques Society also is backing the effort.

The proposal, presented by a NIST scientist, and accepted by the 802 Executive Committee, specifies that the group will develop plans for a "specification of interoperable Local Multipoint Distribution Service (LMDS) systems" in early 1999. The group defined LMDS according to the U.S. frequency allocation, but it plans to define a project on the "coexistence of BWA with other RF systems, and extension to other BWA frequency bands, with the goal of worldwide applicability," by mid-1999. The Study Group, which the 802 Executive Committee named the NIST scientist to chair, held its first meeting in Florida in January 1999.

While the Study Group initiation indicates that BWA standards are being undertaken aggressively by the participants, the new group is inviting participation by all players in the budding worldwide industry. Particularly sought are the license holders and service providers, who are expected to benefit as interoperability standards lead to better, more reliable, and less expensive products. Slides and streaming audio of the Study Group's proposal are available now on the meeting's web page http://nwest.nist.gov/mtg2.html.
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WORKSHOP HELD ON NATIONAL KEY COMPARISONS OF MASS STANDARDS

A workshop for representatives of the U.S. legal metrology system was held in November 1998 at NIST. The workshop focused on developing a protocol and guidelines for a "National Key Comparison of Mass Standards" proposed by NIST. This intercomparison scheme will formally tie together, for the first time, the entire U.S. legal metrology system. Ten states (AZ, CA, CT, GA, IO, NC, ME, MI, MN, and OK) and Puerto Rico represented the regional metrology groups of the U.S. legal metrology system. This scheme follows the international model for key comparisons developed by the International Committee for Weights and Measures Consultative Committees. The intercomparison will be kicked off and completed in the year 2000. In the meantime, preparations are ongoing at all participating laboratories, including NIST, where full characterization of the mass standards that will be circulated among the participants is currently in progress.

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NIST WORKSHOP EXAMINES NEEDS FOR REFERENCE BIOMATERIALS

Priorities for reference biomaterials (RBMs) were established at a recent workshop held at NIST. The priorities strongly reflect the current status of materials selections within three applications of biomaterials—orthopedic, cardiovascular, and tissue-engineered products. A high-priority RBM for the orthopedic industry was identified as particulate ultra high molecular weight polyethylene (UHMWPE) with size, shape, and morphology typical of wear debris found around orthopedic implants. UHMWPE is used widely in artificial joints, but demands for longer use life and higher performance drive the need for improvements in this material. The cardiovascular industry representatives expressed support for the current reference material development efforts but also were concerned about the need to identify more clearly the important properties and to formulate a clear rationale for additional RBMs. They also expressed a variety of opinions on the needs for additional RBMs for cardiovascular materials, reflecting the diversity of materials under consideration. The newly emerging tissue-engineering arena is at an embryonic state relative to its requirements for specific RBMs, and there was no consensus on needs beyond a definite interest in reference tissue cell-lines. A commercial source for providing standard reference cells was identified in the discussions.

The workshop was sponsored by NIST, with cooperation of the National Institutes of Health (NIH), Food and Drug Administration (FDA), and the Society for Biomaterials. About 40 participants registered for the workshop, with 16 representatives from industry. The workshop was motivated by ongoing discussions on RBMs at meetings of the NIH, the American Society for Testing and Materials, and the Society for Biomaterials. There also has been a recently signed agreement (1997) between NIH, NIST, and the FDA for cooperation on the development of needed RBMs.

The workshop featured speakers from NIH, FDA, and the orthopedic, cardiovascular, and emerging tissue engineered products industries. Although the workshop was able to identify a few specific needs, including stable, nonbiased sources for RBMs, it also demonstrated clearly the importance of a continuing dialog to identify new RBMs, with the impetus for such materials seen as arising from defined needs as they appear in national/international consensus standards.

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WORKSHOP HELD ON ASSESSMENT OF MACHINING MODELS

A NIST researcher, co-chaired a workshop on assessment of machining models with a staff member of the National Science Foundation. The workshop, held in conjunction with the International Mechanical Engineering Congress and Exposition, was attended by more than 30 academic researchers. The goal of the assessment effort is to produce "standard" sets of experimental machining data at different laboratories that can be used by modelers worldwide to test their simulation codes. The work is focused on predictive modeling of the tool-chip interface that is a major building block in models for tool wear, as well as for larger enterprise-level models of the manufacturing process. Another NIST researcher also is contributing to this effort and has volunteered to develop a web site to allow access to the experimental data.

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DESIGN/MANUFACTURING INTEGRATION WORKSHOP HELD

NIST sponsored and hosted a workshop on design/manufacturing integration in November 1998. The objectives of this workshop were to provide an open forum for CAD/CAPP/KBS (computer-aided design, computer-aided process planning, knowledge-based system) vendors, engineers, and manufacturers; to identify gaps in current technologies; and to begin proposing solutions to these problems. There were more than 40 attendees, most of whom were from industry (representing both hardware and software production), as well as several representatives from NIST, national laboratories, and academia. Some of the issues that the workshop attendees believe are important for future economic development include the need for interactive references, tools for knowledge capture, data dictionaries, continued STEP (STandard for the Exchange of Product model data) development, and methods for capturing process/plant capabilities.

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NEXT GENERATION LITHOGRAPHY SUPPORT

Extreme ultraviolet lithography (EUVL), operating at a wavelength of approximately 13 nm, is a key contender for the next generation of lithography for feature sizes below 0.1 μm. NIST scientists provided a series of presentations related to this technology at a meeting hosted by a private company. As a result of this exchange, NIST has been asked to provide support in areas including optical figure metrology. Plans will be developed to do comparative measurements between the XCALIBIR optical metrology system at NIST and the in-house interferometry at the private company.

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Calendar

March 22–23, 1999
SECOND ADVANCED ENCRYPTION STANDARD (AES) CANDIDATE CONFERENCE

Location: Hotel Quirinale
Rome, Italy

Sponsor: NIST.
Audience: An international audience consisting of cryptographers and other interested parties who wish to participate in the evaluation and analysis of the fifteen candidate algorithms for the Advanced Encryption Standard.
Format: Presentations, demonstrations, and discussions.
Purpose: In August, 1998, NIST announced fifteen candidate algorithms which have been proposed for consideration for selection as the Advanced Encryption Algorithm to be incorporated in the Federal Information Processing Standard (FIPS) for Advanced Encryption Standard (AES). During the conference, attendees will hear results of experts' study of the fifteen AES candidate algorithms and recommendations for the selection of finalists (five or fewer). Also, NIST will present the results of its efficiency measurements of the candidate's performance. To further ensure a constructive and lively dialogue, submitters of the candidate algorithms will also have an opportunity to provide their comments on the analysis of their algorithms (and on the other candidates). Simply put, the purpose of this conference will be to help answer the question: "Which algorithms merit selection for Round 2 and why?"
Topics: Security analysis, efficiency analysis, as well as other germane comments (e.g., intellectual property).
Technical Contacts: Miles Smid, NIST, 100 Bureau Dr., Stop 8930, Gaithersburg, MD 20899-8930, phone: 301/975-2938, fax: 301/948-1233, email: miles.smid @nist.gov. or Jim Foti, NIST, 100 bureau Dr., Stop 8930, Gaithersburg, MD 20899-8930, phone: 301/975-5237, fax: 301/948-1233, email: james.foti@nist.gov.
Conference Homepage: http://csrc.nist.gov/encryption/aes/aes_home.htm.
Electronic Registration: https://sales.nist.gov/conf/secure/CONF97/conf_register.htm.

March 23–25, 1999
GAGE BLOCK SEMINAR

Location: National Institute of Standards and Technology
Gaithersburg, MD

Sponsor: NIST.
Audience: Industry metrologists.
Format: Lecture.
Purpose: Three-day seminar to reach industrial metrologist's techniques used for high accuracy calibration of gage blocks.
Topics: Definitions and standards, sources of variability, measurement techniques, SPC and uncertainty.
Technical Contact: John Stoup, NIST, 100 Bureau Dr., Stop 8211, Gaithersburg, MD 20899-8211, phone: 301/975-3476, fax: 301/869-0822, email: john.stoup @nist.gov.
Electronic Registration: https://sales.nist.gov/conf/secure/CONF98/conf_register.htm.

April 19–23, 1999
TENTH INTERNATIONAL CONFERENCE ON MODERN TRENDS IN ACTIVATION ANALYSIS

Location: Natcher Conference Center,
National Institutes of Health
Bethesda, MD

Sponsors: NIST: Analytical Chemistry Division, Center for Neutron Research, Standard Reference Materials Program, Office of International and Academic Affairs; American Chemical Society, Nuclear Chemistry Division, American Nuclear Society; Biology & Medicine and Isotopes & Radiation Divisions, American Society for Testing and Materials (ASTM); AOAC International, International Atomic energy Agency; International Group on Research Reactors (IGORR), Smithsonian Institution; U.S. Department of Agriculture; U.S. Food and Drug Administration; center for Food Safety and Applied Nutrition; and The University of Maryland.
Audience: scientists involved in the development and application of neutron activation and other nuclear methods of chemical analysis.

Format: International conference.
Purpose: To develop and apply nuclear techniques of chemical analysis worldwide, with emphasis on innovative recent developments.
Topics: Original and tutorial, invited and contributed, oral and poster papers will be included, and the following topics will be featured: instrumental and radiochemical activation analysis; methods, facilities, instrumentation, nuclear data, data processing, and interpretation; accuracy, standards, sampling, blanks, and background; reference materials, traceability, metrology, quality assurance, and accreditation; environmental, biomedical, geological, archaeological, and industrial applications; extreme activation analysis: large and small samples, short half-lives, ultratrace measurements, and on-line and in-vivo applications; high-rate and low-background radionuclide metrology; charged-particle and photon activation analysis; nuclear track methods; analysis with neutron beams and portable exciting sources; radioactive and activable tracer techniques; comparisons and synergisms with other techniques; education, training, and the future of activation analysis.
Technical Contacts: Richard Lindstrom, NIST, 100 Bureau Dr., Stop 8395, Gaithersburg, MD 20899-8395, phone: 301/975-6281, fax: 301/208-9279 or G. Venkatesh Iyengar, NIST, 100 Bureau Dr., Stop 8395, Gaithersburg, MD 20899-8395, phone: 301/975-6284, fax: 301/208-9279, email: mtaa10@nist.gov.
Conference Homepage: Http://www.cstl.nist.gov/nist839/839.05/MTAA1.htm.
Electronic Registration: https://sales.nist.gov/conf/secure/CONF101/conf_register.htm.

April 25–28, 1999
MALCOLM BALDRIGE NATIONAL QUALITY AWARD QUEST FOR EXCELLENCE XI

Location: Marriott Wardman Park Hotel
Washington, DC

Sponsor: NIST, American Society for Quality (ASQ), American Society for Training and Development (ASTD), and the Association for Quality and Participation (AQP).**Audience:** Business leaders from around the world.
Format: The format of the conference ranges from plenary sessions to lectures to breakout sessions developed around questions and answers from conference participants. The conference is designed to maximize learning and networking opportunities.
Purpose: The Quest for Excellence conference provides a forum for worldwide business leaders to hear about the journeys to business excellence and the exceptional business practices and to question award recipients.
Topics: Topics include the Malcolm Baldrige National Quality Award Criteria for Performance Excellence categories, and the Quality Journey of Award Recipients.
Technical Contacts: Daniel Barton, NIST, 100 Bureau Dr., Stop 1020, gaithersburg, MD 20899-1020, phone: 301/975-3555, fax: 301/948-3716, email: daniel.barton @nist.gov or Sue Rohan, NIST, Bureau Dr., Stop 1020, Gaithersburg, MD 20899-1020, phone: 301/975-4329, fax: 301/948-3716, email: sue.rohan@nist.gov.
National Quality Program Homepage: http://www.quality.nist.gov.

June 7–8, 1999
INTERNATIONAL SYMPOSIUM ON ADVANCED MATERIALS WITH BIOMEDICAL APPLICATIONS

Location: National Institute of
Standards and Technology
Gaithersburg, MD

Sponsors: NIST, National Institutes of Health (NIH), Academy of Dental Materials, American Ceramic society, International Association of Dental Research, Materials Research Society, National Institute of Dental Research, National Science Foundation, and Society for Biomaterials.
Audience: Basic, applied, and clinical scientists.
Format: Conference with parallel sessions and posters.
Purpose: The exchange of recent technical information on advanced materials used in biomedical applications.
Topics: Ceramics, composites, and layer structures; fabrication of materials; mechanical behavior, theory and modeling; and clinical performance.
Technical Contacts: Said Jahanmir, NIST, 100 Bureau Dr., Stop 1060, Gaithersburg, MD 20899-1060, phone: 301/975-3671, fax: 301/975-5334, email: said.jahanmir@nist.gov..
Ceramic Machining Program Homepage: http://www.msel.nist.gov/programs/ceramic_machining/
Electronic Registration: https://sales.nist.gov/conf/secure/CONF93/conf_register.htm.

June 7–11, 1999

CONFERENCE ON RADIONUCLIDE METROLOGY AND ITS APPLICATION

Location: Prague, Czech Republic

Sponsors: NIST and other national standards laboratories.
Audience: Scientists involved in measurements of radioactivity.
Format: Conference with oral presentations and poster papers.
Purpose: To inform participants on recent developments in radionuclide metrology.
Topics: Radionuclide metrology techniques, source preparation, measurement standards and reference materials, alpha-particle spectrometry, beta-particle spectrometry, gamma-ray spectrometry, nuclear decal data, life sciences, and low-level radioactivity measurements.
Technical Contact: Bert Coursey, NIST, 100 Bureau Dr., Stop 8460, Gaithersburg, MD 20899-8460, phone: 301/975-5584, fax: 301/869-7682, email: bert.coursey @nist.gov.
Conference Homepage:
http://www.cmi.cz/E-index.html.

June 21–22, 1999

TIME AND FREQUENCY SEMINAR: INTRODUCTION LEVEL I

Location: The Broker Inn
Boulder, CO

Sponsor: NIST.
Audience: Beginning mathematicians, scientists, engineers, educators, managers, and planners involved in the use of time and frequency systems.
Format: Seminar.
Purpose: To present techniques related to the analysis and evaluation of oscillators and frequency standards. A variety of modern electronic systems depend critically on precise timing on an ultra-stable frequency reference. The clocks and oscillators in such systems must, therefore, be characterized carefully. This seminar focuses on common methods of measuring and interpreting oscillator and clock performance and how these results affect overall system performance.
Topics: Fundamentals of time and timekeeping, definition of terms, measurement methods, analysis techniques in the time domain and frequency domain, methods of synchronization, specifying time and frequency-based systems, and performance and specifications of quartz oscillators.
Technical Contact: John Lowe, NIST, 325 Broadway, Mailcode 847.40, Boulder, CO 80303-3328, phone: 303/497-5453, fax: 303/497-6461, email: lowe@ boulder.nist.gov.
Time and Frequency Seminar Homepage:
http://www.bldrdoc.gov/timefreq/seminar.htm.

June 23–25, 1999

TIME AND FREQUENCY SEMINAR: FUNDAMENTALS LEVEL II

Location: The Broker Inn
Boulder, CO

Sponsor: NIST.
Audience: Engineers, scientists, and laboratory technicians involved in the application and use of high-performance time and frequency systems. It is particularly appropriate for those who are, or might be responsible for certification of oscillator performance at levels where traceability to national standards is a useful part of this certification.
Format: Seminar.
Purpose: Participants will first learn the specialized measurement techniques for quantifying frequency stability and spectral purity of an oscillator. Second, typical commercial oscillators and atomic frequency standards will be described with explanations for their composite parts. An overview of methods of timekeeping and synchronization will follow along with an introduction to available time and frequency services. Finally, present-day levels of performance will be outlined along with prospects regarding the future.
Topics: Short term stability, long term stability, and measurement techniques; spectral purity and measurements; performance and specifications of quartz oscillators; characteristics of commercial frequency standards; synchronization in network systems; timekeeping and time scales; GPS and other dissemination services.
Technical Contact: John Lowe, NIST, 325 Broadway, Mailcode 847.40, Boulder, CO 80303-3328, phone: 303/497-5453, fax: 303/497-6461, email: lowe@ boulder.nist.gov.
Time and Frequency Seminar Homepage:
http://www.bldrdoc.gov/timefreq/seminar.htm.

October 18–22, 1999

1999 PRECISION THERMOMETRY WORKSHOPS

Location: National Institute of Standards and Technology Gaithersburg, MD

Sponsor: NIST.

Audience: Calibration laboratory personnel and others who wish to undertake precision temperature measurements. Applicants should possess undergraduate training in physics or engineering and should have some laboratory experience in metrology. Participation is limited to 16 people. There is no on-site registration.

Format: Classroom and laboratory instruction.

Purpose: To provide advice and assistance on measurement and calibration problems, tracing to NIST the accuracies of measurement standards needed for research work, factory production, or field evaluation.

Topics: Temperature scales, platinum resistance thermometry, vapor pressure and gas thermometry, low temperature calibrations, thermistor thermometry, liquid-in-glass thermometry, and thermocouple thermometry.

Technical Contact: Andrea Swiger, NIST, 100 Bureau Dr., Stop 8363, Gaithersburg, MD 20899-8363, phone: 301/975-4800, email: andrea.swiger@nist.gov.

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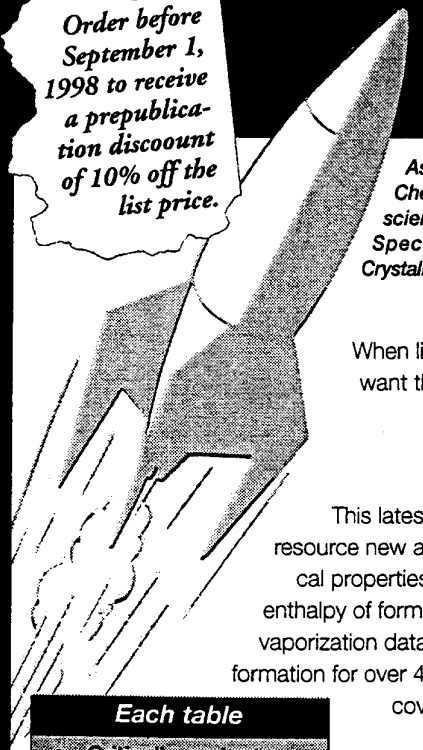

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Uncertain about expressing measurement uncertainty? Do you need to know how NIST states the uncertainty of its measurement results and how you can implement their internationally accepted method in your own laboratory? Then you need the newly available 1994 edition of the National Institute of Standards and Technology Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results.*

The 1994 edition of the National Institute of Standards and Technology Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, by Barry N. Taylor and Chris E. Kuyatt is now available.

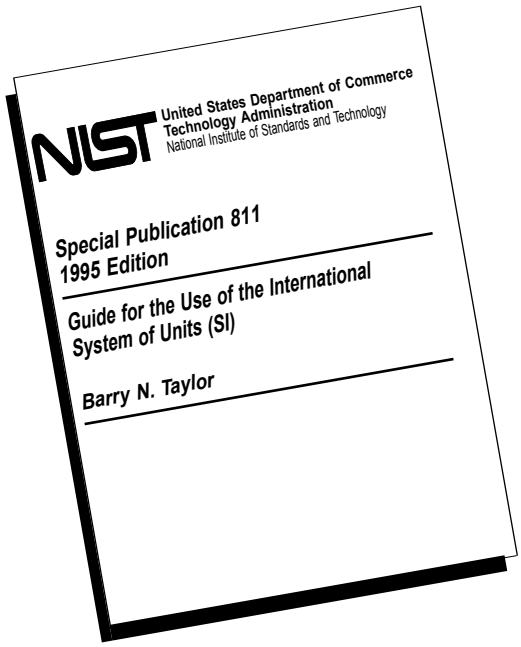
The 1994 edition of TN 1297 includes a new appendix—Appendix D—which clarifies and gives additional guidance on a number of topics related to measurement uncertainty, including the use of certain terms such as accuracy and precision. Very minor word changes have also been made in a few portions of the text of the 1993 edition in order to recognize the official publication in October 1993 by the International Organization for Standardization (ISO) of the *Guide to the Expression of Uncertainty in Measurement* on which TN 1297 is based. However, the NIST policy on measurement uncertainty, Statements of Uncertainty Associated with Measurement Results, which is reproduced as Appendix C of TN 1297, is unchanged.

It is expected that the 1994 edition of TN 1297 will be even more useful than its immediate predecessor, the 1993 edition, of which 10 000 copies were distributed worldwide.

Those United States readers who wish to delve into the subject of measurement uncertainty in greater depth may purchase a copy of the 100-page ISO *Guide* from the Sales Department of the American National Standards Institute (ANSI), 105-111 South State Street, Hackensack, NJ 07601. Copies may also be purchased from the ISO Central Secretariat, 1 rue de Varembé, Case postale 56, CH-1211 Genève 20, Switzerland.

Single copies of the 20-page TN 1297 may be obtained from the NIST Calibration Program, Building 820, Room 232, Gaithersburg, MD 20899-0001, telephone: 301-975-2002, fax: 301-948-3825.

The International System of Units (SI)
The Modern Metric System



Uncertain about the International System of Units (universally abbreviated SI), the modern metric system used throughout the world? Do you need to know the proper way to express the results of measurements and the values of quantities in units of the SI? Do you need to know the NIST policy on the use of the SI? Then you need the 1995 edition of the National Institute of Standards and Technology Special Publication 811, *Guide for the Use of the International System of Units (SI)*.

The 1995 edition of the National Institute of Standards and Technology Special Publication 811, *Guide for the Use of the International System of Units (SI)*, by Barry N. Taylor, is now available.

The 1995 edition of SP 811 corrects a number of misprints in the 1991 edition, incorporates a significant amount of additional material intended to answer frequently asked questions concerning the SI and SI usage, and updates the bibliography. The added material includes a check list for reviewing the consistency of written documents with the SI. Some changes in format have also been made in an attempt to improve the ease of use of SP 811.

The topics covered by SP 811 include:

- NIST policy on the use of the SI in NIST publications.
- Classes of SI units, those SI derived units that have special names and symbols, and the SI prefixes that are used to form decimal multiples and submultiples of SI units.
- Those units outside the SI that may be used with the SI and those that may not.
- Rules and style conventions for printing and using quantity symbols, unit symbols, and prefix symbols, and for spelling unit names.
- Rules and style conventions for expressing the results of measurements and the values of quantities.
- Definitions of the SI base units.
- Conversion factors for converting values of quantities expressed in units that are mainly unacceptable for use with the SI to values expressed mainly in units of the SI.
- Rounding numbers and rounding converted numerical values of quantities.

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